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(54) Arc welder or cutter with DC arc-initiation assisting circuit

(57) An arc welding or cutting apparatus has a charging/discharging means 146 which assists an HF generator 140 to initiate a DC arc when a workpiece 114 is more positive than a welding or cutting torch 124. The apparatus has a rectifier 104, a high frequency inverter 106 driving a transformer 108, and a rectifier 117, 118 which rectifies the output of transformer 108 so that workpiece 114 is positive relative to torch 124. To start the arc, a switch 150 is closed so that a capacitor 148 in the assisting means 146 is charged via a resistor 147 from rectifier 117, 118. When the HF generator 140 is subsequently started, the capacitor 148 discharges via a diode 152 to supply current from workpiece 114 to torch 124, thereby assisting the generator 140 in initiating the DC arc. The switch 150 may remain closed during the welding or cutting operation, or may be opened after the arc has started.

In apparatus which is selectively operable in AC or DC arc mode, rectifier 117, 118 maintains a line 130 negative relative to a line 110. Line 110 is connected to workpiece 114 and to a centre tap of transformer 108, which has another rectifier 115, 116 to maintain a line 120 positive relative to line 110. In AC arc operating mode, switches 128 and 134 in lines 120, 130 are alternately turned on and off out of phase with one another, so that torch 124 is alternately positive and negative relative to workpiece 114; the switch 150 is maintained off so that the capacitor 148 is not used to assist arc initiation in the AC mode. In DC arc mode, switch 128 remains off, and switches 134 and 150 are turned on.

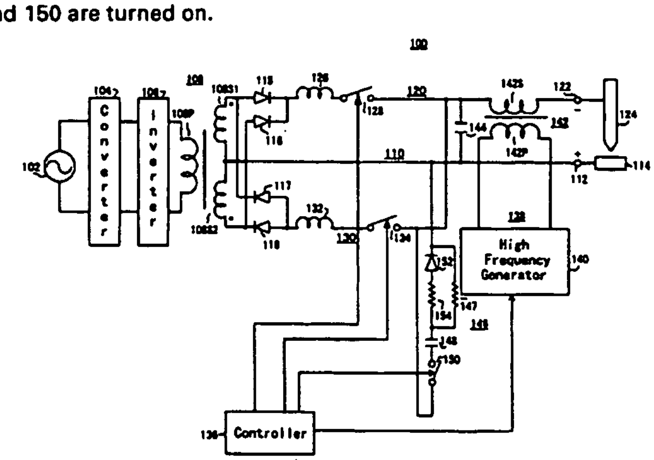

FIG. 2

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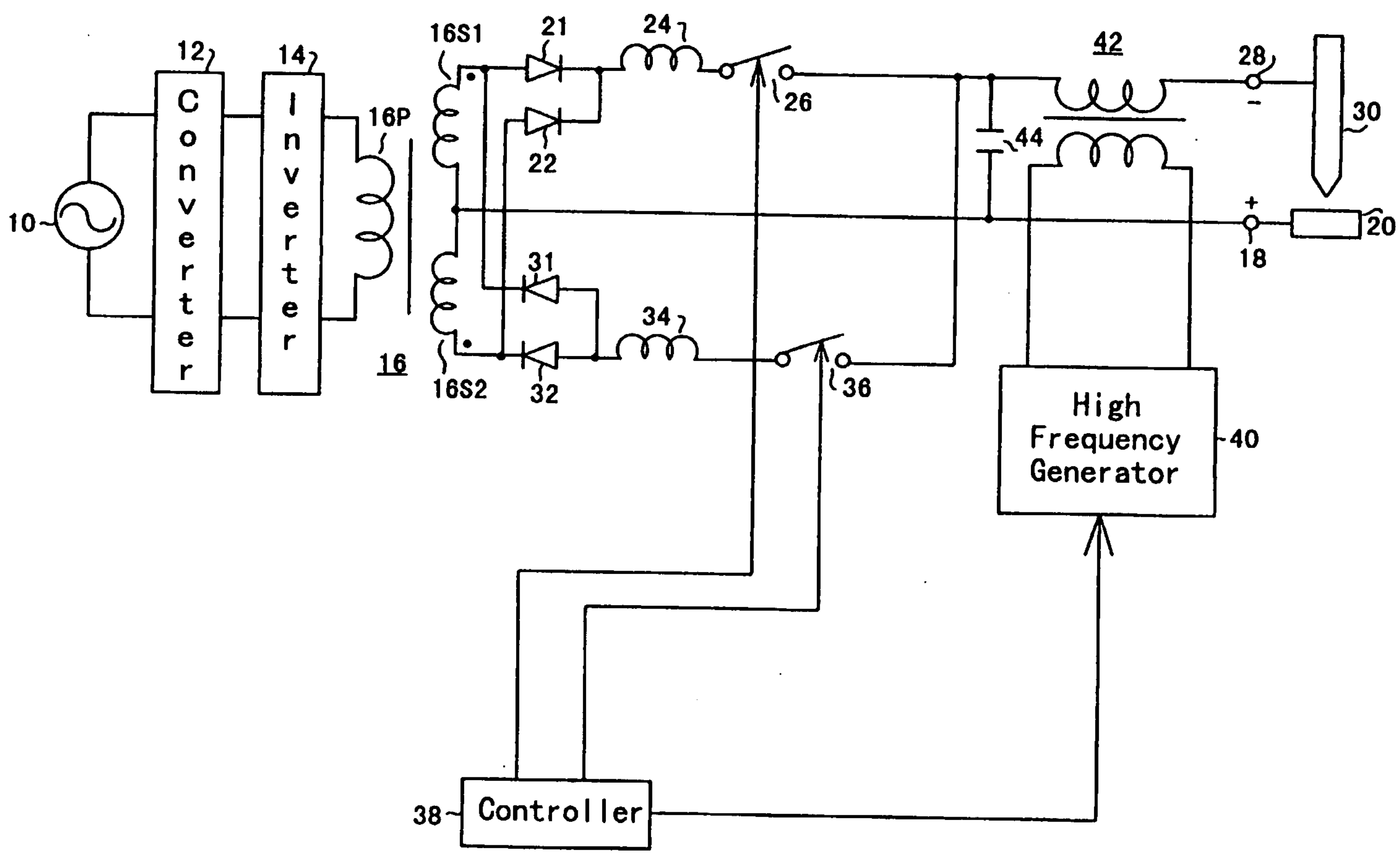

FIG. 1 Prior Art

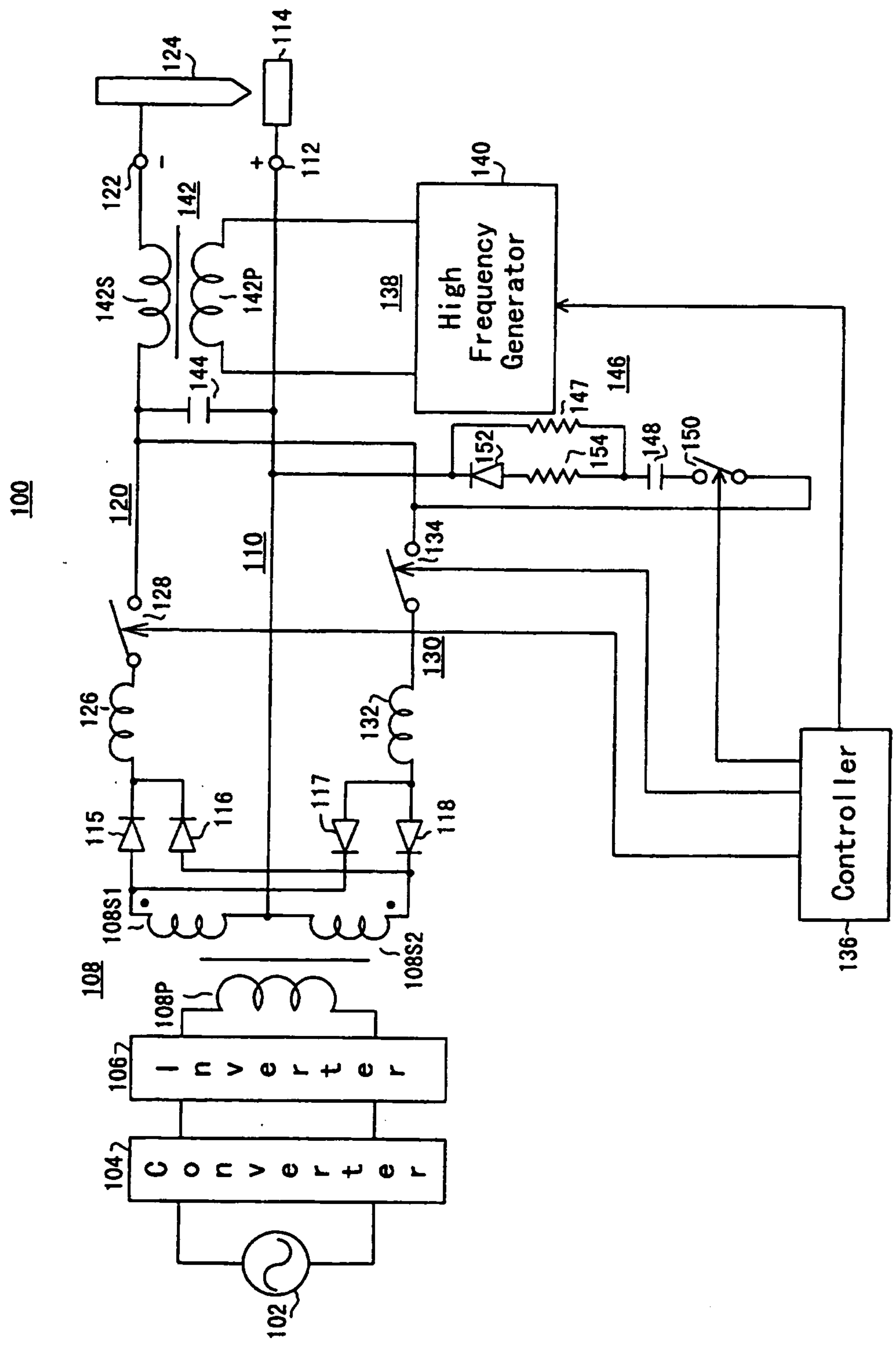
100
102
104
Converter
106
Inverter
108
108P
108S1
108S2
110
112
+
114
115
116
117
118
120
122
-
124
126
128
130
132
134
136
Controller
138
140
High
Frequency
Generator
142
142P
142S
144
146
147
148
150
152
154

FIG. 2

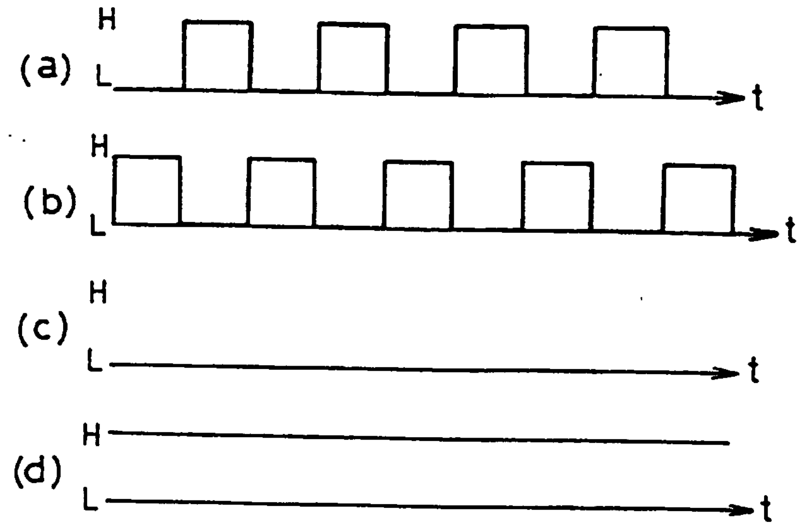

FIG. 3

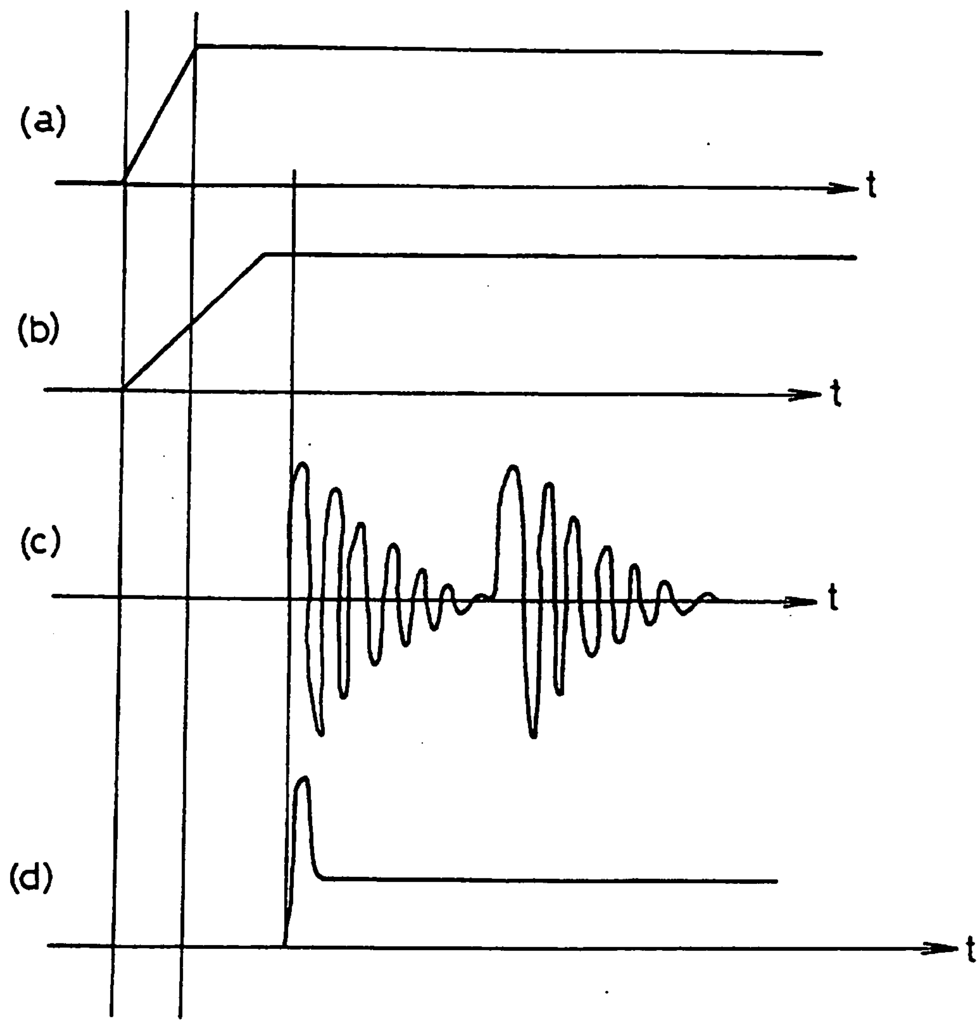

FIG. 4

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POWER SUPPLY APPARATUS WITH DC-ARC INITIATION ASSISTING CIRCUIT

This application is based on Japanese Patent Application No. HEI 8-354436 filed on December 18, 1996, which is incorporated hereinto by reference.

This invention relates to power supply apparatus used with arc utilizing equipment such as an arc cutter and an arc welder, and, in particular, to such power supply apparatus having a DC-arc initiation assisting circuit.

BACKGROUND OF THE INVENTION

Some conventional power supply apparatus used with arc utilizing equipment, e.g. an arc welder, are arranged to selectively supply AC and DC current to a load comprising a torch of the welder and a workpiece to be wrought. One example of such AC/DC power supply apparatus for an arc welder is shown in FIGURE 1.

In the power supply apparatus of FIGURE 1, a commercial AC voltage from a commercial AC power supply 10 is converted into a DC voltage by a converter 12. The DC voltage from the converter 12 is converted into a high frequency voltage by an inverter 14. The high frequency voltage is applied to a primary winding 16P of an isolation transformer 16, and a voltage-transformed high frequency voltage is induced in each of two secondary windings 16S1 and 16S2 of the isolation transformer 16.

The secondary windings 16S1 and 16S2 are wound in such a manner that the voltages induced in the respective windings 16S1 and 16S2 exhibit the same polarity at the ends of the respective windings with dots. The respective other, undotted ends of the windings 16S1 and 16S2 are interconnected and coupled to an output terminal 18. The

terminal 18 is connected to a workpiece 20. The dotted ends of the windings 16S1 and 16S2 are connected to the anodes of diodes 21 and 22, respectively. The cathodes of the diodes 21 and 22 are interconnected, and coupled to an output terminal 28 via a smoothing reactor 24 and a switching element 26. The output terminal 28 is connected to a torch 30.

The dotted end of the winding 16S1 is connected also to the cathode of a diode 31, and the dotted end of the winding 16S2 is connected also to the cathode of a diode 32. The anodes of the diodes 31 and 32 are interconnected and coupled to the output terminal 28 via a smoothing reactor 34 and a switching element 36. The switching elements 26 and 36 are turned on and off by a controller 38.

When the switching element 26 is turned on, current flows from the secondary windings 16S1 and 16S2 through the diodes 21 and 22, the smoothing reactor 24, the switching element 26, the output terminal 28, the torch 30, the workpiece 20, and the output terminal 18 back to the secondary windings 16S1 and 16S2. When the switching element 36 is turned on, current flows from the secondary windings 16S1 and 16S2 through the output terminal 18, the workpiece 20, the torch 30, the output terminal 28, the switching element 36, the smoothing reactor 34 and the diodes 31 and 32 back to the secondary windings 16S1 and 16S2. Thus, it is seen that AC current can be applied between the workpiece 20 and the torch 30 by alternately enabling the switching elements 26 and 36. DC current can be applied between the workpiece 20 and the torch 30 by disabling one of the switching elements 26 and 36. Preferably, the switching element 36 should be enabled with the switching element 26 disabled because the workpiece 20 can be more easily melted when it is kept more positive than the torch 30.

To generate an arc across a gap between the torch 30 and the

workpiece 20, a high frequency generator 40 is used. A high frequency, high voltage generated by the high frequency generator 40 is applied between the torch 30 and the workpiece 20 through a coupling transformer 42 and a bypass capacitor 44, whereby arcing is initiated. The above-mentioned AC or DC current is used for sustaining arcing.

As stated above, the workpiece 20 is placed more positive than the torch 30 so that the workpiece 20 can be easily melted. Thus, current flows from the workpiece 20 to the torch 30. In other words, electrons flow from the torch 30 to the workpiece 20. It is known, however, that arcing can be more easily initiated by applying a high frequency voltage between the workpiece 20 and the torch 30 with the torch 30, rather than the workpiece 20, being more positive so that electrons flow from the workpiece 20 to the torch 30. In the power supply apparatus of FIGURE 1, however, the workpiece 20 is more positive than the torch 30, and, therefore, it is sometimes difficult to initiate arcing by the high frequency generator 40 alone.

SUMMARY OF THE INVENTION

The present invention can overcome the problem stated above. Power supply apparatus according to the present invention have a DC-arc initiation assisting circuit. In accordance with a first aspect of the present invention, power supply apparatus includes inverter means for converting a DC voltage into a high frequency voltage and a transformer having a primary winding and a secondary winding. The primary winding receives the high frequency voltage from the inverter means, and the secondary winding has a voltage-transformed high frequency voltage induced therein. Converter means converts the voltage-transformed high frequency voltage induced in the secondary winding into a DC voltage for application between a first output terminal and a second output terminal. The first output terminal is

kept more positive than the second output terminal. The first output terminal is adapted to be connected to a workpiece to be wrought. The second output terminal is adapted to be connected to a torch of electrical equipment, such as an arc welder and an arc cutter, for which the power supply apparatus is used. High frequency voltage applying means applies between the first and second output terminals, a high frequency, high voltage different from the high frequency voltage provided by the inverter means. Current supply means is also connected between the first and second output terminals for supplying current to flow from the first output terminal to the second output terminal.

In the arrangement described above, the converter means applies a DC voltage between the first and second output terminals in such a polarity that the first output terminal to be connected to the workpiece can be more positive and the second output terminal to be connected to the torch can less positive. With the torch and the workpiece maintained in this polarity relationship, arcing is hardly initiated between the torch and the workpiece even when a high frequency voltage from the high frequency voltage applying means is applied between the first and second output terminals. To initiate arcing, the current supply means supplies current to flow between the first and second output terminals when the high frequency voltage is applied between the first and second output terminals. This helps arcing be more easily initiated because both the converter means and the current supply means supply current to flow between the first and second output terminals.

The current supply means may be charging/discharging means to which the output voltage of the converter means is applied.

With this arrangement, the current supply means is charged from the output from the converter means, and discharges to supply current

to flow between the first and second output terminals when the high frequency voltage applying means applies the high frequency voltage between the first and second output terminals. Thus, the current supply means requires no dedicated power source because it is charged from the output of the converter means.

The power supply apparatus according to a second aspect of the present invention includes inverter means, a transformer, first and second output terminals, and rectifying means. The inverter means converts a DC voltage into a high frequency voltage. The transformer has a primary winding receiving the high frequency voltage from the inverter means, and two secondary windings each having a voltage-transformed high frequency voltage induced therein. The first output terminal is adapted to be connected to a workpiece and the second output terminal is adapted to be connected to a torch. The rectifying means are connected via each of first and second paths to the second output terminal and connected via a third path to the first output terminal. The rectifying means receives the voltage-transformed voltages induced in the secondary windings of the transformer, and rectifies them in such a manner that current can flow through the workpiece and the torch, from the first path to the third path, or from the third path to the second path. The first path includes a first switching element, and the second path includes a second switching element. Control means controls the first and second switching elements to place them in a selected one of first and second states. In the first state, the control means alternately turns on and off the first and second switching elements in a complemental fashion. In the second state, the first switching element is turned off and the second switching element is turned on. High frequency voltage applying means applies a high frequency, high voltage, different from the high frequency voltage provided by the inverter

means, between the first and second output terminals. When the first and second switching elements are in the second state and the high frequency voltage applying means applies the high frequency voltage between the first and second output terminals, current supply means supplies current from the third path to the second path.

In the arrangement stated above, when the high frequency voltage applying means applies the high frequency voltage between the first and second output terminals with the control means placing the first and second switching elements in the first state in which the switching elements are alternately and complementarily turned on and off, arcing is initiated, so that arc current starts to flow between the first and second output terminals.

Alternatively, the control means can place the switching elements in the second state in which the first switching element is turned off and the second switching element is turned on. With the switching elements in the second state, the high frequency voltage applying means applies the high frequency voltage between the first and second output terminals, to thereby initiate arcing therebetween, and the current supply means and the rectifying means supply current to flow between the first and second output terminals for sustaining the arcing.

In the power supply apparatus according to the second aspect of the present invention, the current supply means may be charging/discharging means which receives an output voltage from the rectifying means. The current supply means is charged from the output of the rectifying means. Then, the current supply means discharges to supply current to flow between the first and second output terminals when the high frequency voltage applying means applies the high frequency voltage between the first and second output terminals. Since the current supply means is charged from the

output of the rectifying means, it advantageously requires no dedicated power source therefor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a prior AC/DC power supply apparatus used with an arc welder;

FIGURE 2 is a circuit diagram of AC/DC power supply apparatus with a DC-arc initiation assisting circuit according to one embodiment of the present invention used with an arc welder;

FIGURE 3 shows waveforms of drive signals developed by a controller shown in FIGURE 2; and

FIGURE 4 shows waveforms of signals developed at various portions of the apparatus shown in FIGURE 2 during its DC operation.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

AC/DC power supply apparatus according to an embodiment of the present invention as used with a welder is explained below with reference to the attached FIGURES 2 through 4.

As shown in FIGURE 2, the AC/DC power supply apparatus 100 has a converter 104 receiving a commercial AC voltage from a commercial AC power supply 102. The commercial AC power supply 102 may be a commercial three-phase or single-phase AC power supply. The converter 104 includes rectifying means, e.g. a full-wave rectifying circuit or a half-wave rectifying circuit, and smoothing means, e.g. a smoothing capacitor, and converts an AC voltage applied thereto into a DC voltage.

The converter 104 applies the DC voltage to an inverter 106. The inverter 106 is a known one, which includes plural, e.g. two or four, bridge-connected semiconductor switching elements. The semiconductor switching elements are ON/OFF controlled in accordance

with a control signal applied from a control device (not shown) so that the DC voltage is transformed into a high frequency voltage having a frequency of e.g. several tens of kilohertz. The semiconductor switching elements may be, for example, insulated gate bipolar transistors, power FETs, or power bipolar transistors.

The high frequency voltage from the inverter 106 is applied to a primary winding 108P of a transformer, e.g. an isolation transformer 108. The primary winding 108P is wound on a core. Two secondary windings 108S1 and 108S2 are also wound on the core in such a manner that voltages induced in the windings 108S1 and 108S2 when the high frequency voltage is applied to the primary winding 108P can exhibit the same polarity at respective ones of the ends of the windings 108S1 and 108S2 shown dotted in FIGURE 2.

The undotted ends of the secondary windings 108S1 and 108S2 are interconnected and coupled to an output terminal 112 via a path 110. The output terminal 112 is connected to a workpiece 114. The dotted ends of the windings 108S1 and 108S2 are connected respectively to the anodes of rectifying means, e.g. diodes 115 and 116. The cathodes of the diodes 115 and 116 are interconnected. Similarly, the cathodes of another rectifying means, e.g. diodes 117 and 118, are connected respectively to the dotted ends of the secondary windings 108S1 and 108S2. The anodes of the diodes 117 and 118 are interconnected.

The cathodes of the diodes 115 and 116 are coupled to an output terminal 122 via a path 120. The output terminal 122 is connected to a torch 124 of the welder. The path 120 includes smoothing means, e.g. a smoothing reactor 126, and a switching element 128 connected in series with the smoothing reactor 126. The anodes of the diodes 117 and 118 are coupled to the output terminal 122 via a path 130. The path 130 includes smoothing means, e.g. a smoothing reactor 132, and a switching element 134 connected in series with the smoothing reactor

132. The switching elements 128 and 134 may be semiconductor switching elements, such as insulated gate bipolar transistors, power FETs, and power bipolar transistors. The switching elements 128 and 134 are turned on when switching element driving signals applied thereto from a controller 136 are in a first state, e.g. at a high level (H-level), and turned off when the driving signals are in a second state, e.g. at a low level (L-level).

The diodes 115 and 116 and the smoothing reactor 126 constitute a converter, of which a more positive output is at the junction of the smoothing reactor 126 and the semiconductor switching element 128, and of which a less positive output is at the junction of the secondary windings 108S1 and 108S2. The diodes 117 and 118 and the smoothing reactor 132 constitute another converter, of which a less positive output is at the junction of the smoothing reactor 132 and the switching element 134, and of which a more positive output is at the junction of the secondary windings 108S1 and 108S2.

When the switching element 128 is turned on, the switching element 134 is turned off. High frequency voltages are induced in the secondary windings 108S1 and 108S2 with their dotted ends being more positive, so that current flows from the windings 108S1 and 108S2 through the diodes 115 and 116, the smoothing reactor 126, the semiconductor switching element 128, the secondary winding 142S of a coupling transformer 142 which will be described later, the torch 124, and the workpiece 114 back to the windings 108S1 and 108S2.

In contrast, when the switching element 128 is turned off, the switching element 134 is turned on. High frequency voltages are induced in the secondary windings 108S1 and 108S2 with their dotted ends being less positive, so that current flows from the junction of the windings 108S1 and 108S2 through the workpiece 114, the torch 124, the secondary winding 142S, the switching element 134, the reactor

132, and the diodes 117 and 118 back to the windings 108S1 and 108S2. In this way, AC current can flow between the torch 124 and the workpiece 114 by complementarily and alternately turning on and off the semiconductor switching elements 128 and 134.

The controller 136 develops a driving signal to be applied to the switching element 128, in response to an AC-operation command applied through an operation selecting switch (not shown). The driving signal alternates between an H-level and an L-level, as shown in FIGURE 3(a). The controller 136 also develops a driving signal to be applied to the switching element 134 which alternates between an H-level and an L-level and has a phase difference of 180° from the driving signal to be applied to the switching element 128, as shown in FIGURE 3(b).

The controller 136, when a DC-operation command is applied thereto through the operation selecting switch, maintains the driving signal for the switching element 128 at the L-level, as shown in FIGURE 3(c), and also maintains the driving signal for the switching element 134 at the H-level, as shown in FIGURE 3(d). The controller 136 may include a microcomputer which can execute a program for providing the aforementioned driving signals. The driving signals may have a frequency within the range of e.g. 20-150 Hz.

A high frequency voltage applying circuit 138 is disposed between the output terminals 112 and 122. The circuit 138 includes a high frequency generator 140. The high frequency generator 140 generates a high frequency, high voltage in response to a START signal applied thereto from the controller 136. The high frequency voltage generated by the generator 140 has an amplitude gradually decreasing over a series of cycles. One cycle has a period of several nanoseconds, and one series of such cycles has a period of several milliseconds. The high frequency voltage continues to be

generated until a STOP signal is applied from the controller 136 to the generator 140.

The high frequency voltage is applied to a primary winding 142P of the coupling transformer 142. The secondary winding 142S is connected in series with a bypass capacitor 144 between the output terminals 112 and 122 . The ratio in number of turns between the primary winding 142P and the secondary winding 142S is so determined that a high frequency voltage having the peak value of e.g. several kilovolts can be induced in the secondary winding 142S. The high frequency voltage induced in the secondary winding 142S is applied between the output terminals 112 and 122 via the bypass capacitor 144. The bypass capacitor 144 prevents current based on the high frequency voltage induced in the winding 142S from flowing into the diodes 115, 116, 117 and 118.

The bypass capacitor 144 is coupled in parallel with current supply means, e.g. a charging/discharging circuit 146. The charging/discharging circuit 146 includes a series circuit including a charging resistor 147, a capacitor 148 and a switching element 150. The switching element 150 may be a semiconductor switching element, such as an insulated gate bipolar transistor, a power FET and a power bipolar transistor. The series circuit is connected in parallel with the bypass capacitor 144. The switching element 150 receives a driving signal from the controller 136. The switching element 150 is turned on when the driving signal is in a first state, e.g. at an H-level, and turned off when the driving signal is in a second state, e.g. at an L-level. The controller 136 applies the H-level driving signal to the switching element 150 in response to the DC-operation command applied thereto through the operation selecting switch.

A series circuit of a diode 152 and a discharging resistor 154 is connected in parallel with the charging resistor 147. The diode

152 has its anode connected to the discharging resistor 154 and its cathode connected to the output terminal 112. The controller 136 applies the START signal to the high frequency generator 140 a predetermined time after the driving signal applied to the switching element 150 changes to the H-level. The predetermined time is the time necessary for fully charging the capacitor 148 and can be determined from the capacitance of the capacitor 148 and the resistance of the charging resister 147.

In the power supply apparatus 100 having the arrangement described above, the controller 136 applies the driving signals shown in FIGURES 3(a) and 3(b) respectively to the switching elements 128 and 134 in response to the AC-operation command applied to the controller 136. The high frequency voltage provided by the converter 106 is voltage-transformed by the transformer 108, so that the voltage-transformed voltages are induced in the secondary windings 108S1 and 108S2 of the transformer 108. When the voltage-transformed voltages induced in the windings 108S1 and 108S2 have such polarities that they render the dotted ends of the windings 108S1 and 108S2 more positive, they are rectified by the diodes 115 and 116. When the dotted ends are rendered more negative, the diodes 117 and 118 rectify the induced voltages.

There is a gap between the torch 124 and the workpiece 114. Therefore, current does not flow between the torch 124 and the workpiece 114 by merely turning on and/or off the switching elements 128 and 134, and, thus, arcing is not initiated. To initiate arcing, a high frequency voltage is generated by the high frequency generator 140 and then voltage-transformed by the coupling transformer 142 to a voltage of several kilovolts. The voltage of several kilovolts is applied between the workpiece 114 and the torch 124. Thus, an electrical breakdown occurs in the gap between the workpiece 114 and

the torch 124, so that arcing is initiated.

When the semiconductor switching element 128 is turned on in this state, current flows from the windings 108S1 and 108S2 through the diodes 115 and 116, the smoothing reactor 126, the semiconductor switching element 128, the secondary winding 142S, the output terminal 122, the torch 124, the workpiece 114, and the output terminal 112 back to the secondary windings 108S1 and 108S2, to thereby sustain arcing.

When the semiconductor switching element 134 is turned on, current flows from the secondary windings 108S1 and 108S2 through the output terminal 112, the workpiece 114, the torch 124, the output terminal 122, the secondary winding 142S, the semiconductor switching element 134, the smoothing reactor 132, and the diodes 117 and 118 back to the windings 108S1 and 108S2, to thereby sustain arcing.

The direction of current flowing between the torch 124 and the workpiece 114 alternates, depending on which of the semiconductor switching elements 128 and 134 is turned on. That is, arcing is sustained by AC current.

The controller 136, in response to the DC-operation command, provides the semiconductor switching element 128 with the L-level driving signal as shown in FIGURE 3(c), and the semiconductor switching element 134 with the H-level driving signal as shown in FIGURE 3(d). Also, the controller 136 provides the semiconductor switching element 150 with the H-level driving signal. Thus, the semiconductor switching element 128 is turned off and the semiconductor switching elements 134 and 150 are turned on.

This increases the voltage between the output terminals 112 and 122, i.e. between the torch 124 and the workpiece 114, as shown in FIGURE 4(a), but it cannot cause current (i.e. arc current) to flow between the torch 124 and the workpiece 114 because of the gap

therebetween, as shown in FIGURE 4(d). The capacitor 148 begins to be charged through the charging resistor 147, and the voltage across the capacitor 148 becomes higher as shown in FIGURE 4(b).

The controller 136 enables the high frequency generator 140 for generating a high frequency voltage a given time after the completion of the charging of the capacitor 148. The enabling of the high frequency generator 140 may be performed in the following way. The microcomputer of the controller 136, for example, may be arranged to provide a timer in which the time required for charging the capacitor 148 plus a given time is set. The timer is started in response to the DC-operation command applied to the controller 136. The controller 136 applies the START signal to the high frequency generator 140 at the expiration of the set time, so that the high frequency generator 140 generates a high frequency voltage.

The high frequency voltage generated by the generator 140 initiates arcing between the torch 124 and the workpiece 114, which causes a high frequency current as shown in FIGURE 4(c) to flow therebetween. Then, current flows from the secondary windings 108S1 and 108S2 of the transformer 108, through the output terminal 112, the workpiece 114, the torch 124, the output terminal 122, the secondary winding 142S of the coupling transformer 142, the semiconductor switching element 134, the smoothing reactor 132, and the diodes 117 and 118, back to the secondary windings 108S1 and 108S2. Simultaneously, the capacitor 148 is discharged through the discharging resistor 154, the diode 152, the output terminal 112, the workpiece 114, the torch 124, the output terminal 122, the secondary winding 142S of the coupling transformer 142, and the semiconductor switching element 150, back to the capacitor 148.

Thus, the current flowing through the two paths is applied between the torch 124 and the workpiece 114. In other words, arc

current at a considerably high level flows therebetween, as shown in FIGURE 4(d). Therefore, arcing is initiated and sustained even when the workpiece 114 is more positive than the torch 124. The charging/discharging circuit 146 requires no dedicated voltage source therefor because the charging/discharging circuit 146 for sustaining arcing is powered through components such as the secondary windings 108S1 and 108S2 of the transformer 108 and the diodes 117 and 118.

As shown in FIGURE 4(b), the voltage across the capacitor 148 can be kept substantially constant even after the capacitor 148 is discharged, by properly selecting the ratio in resistance between the resistors 147 and 154 and the capacitance of the capacitor 148. After the completion of the discharging, the semiconductor switching element 150 may be turned off. Alternatively, it may be kept on because substantially no charging current flows into the capacitor 148 if the voltage between the output terminals 112 and 122 is stable.

The present invention is described as being embodied in an AC/DC power supply apparatus for an arc welder, but it may be embodied in a power supply apparatus which provides only DC power. Such apparatus does not require e.g. the secondary winding 108S1 of the transformer 108, the diodes 115 and 116, and the semiconductor switching elements 128 and 134. The smoothing reactor 132, then, is connected directly to the secondary winding 142S of the coupling transformer 142.

In addition, in the described embodiment, the diodes 115, 116, 117 and 118 are used to apply a relatively increased current to the output terminals 112 and 122. But, the diodes 116 and 117 can be omitted if smaller current can be used.

Furthermore, the power supply apparatus of the present invention may be used with an arc cutter as well as an arc welder.

What is Claimed is:

1. Power supply apparatus with a DC-arc initiation assisting circuit for assisting the initiation of DC arcing in an arc utilizing equipment, comprising:

inverter means for converting a DC voltage into a high frequency voltage;

a transformer having a primary winding receiving the high frequency voltage from said inverter means and a secondary winding having a voltage-transformed high frequency voltage induced therein; and

converter means for converting said voltage-transformed high frequency voltage into a DC voltage and providing the resulting DC voltage between a first output terminal and a second output terminal, said first output terminal being more positive than said second output terminal and being adapted to be connected to a workpiece to be wrought by said arc utilizing equipment, said second output terminal being adapted to be connected to a torch of said arc utilizing equipment;

said DC-arc initiation assisting circuit comprising:

high frequency voltage applying means for applying a high frequency, high voltage different from the high frequency voltage provided by said inverter means, between said first and second output terminals; and

current supply means connected between said first and second output terminals for supplying current to flow from said first output terminal to said second output terminal.

2. The power supply apparatus according to Claim 1 wherein said current supply means comprises charging/discharging means which

receives an output voltage from said converter means.

3. AC/DC power supply apparatus with a DC-arc initiation assisting circuit used with arc utilizing equipment, said power supply apparatus comprising:

inverter means for converting a DC voltage into a high frequency voltage;

a transformer having a primary winding receiving the high frequency voltage from said inverter means and two secondary windings each having a voltage-transformed high frequency voltage induced therein;

a first output terminal adapted to be connected to a workpiece to be wrought by said arc utilizing equipment;

a second output terminal adapted to be connected to a torch of said arc utilizing equipment;

rectifying means connected via each of first and second paths to said second output terminal and connected via a third path to said first output terminal, said rectifying means rectifying the voltage-transformed high frequency voltages applied thereto in such a manner that current can flow through said workpiece and said torch, from said first path to said third path, or from said third path to said second path;

a first switching element disposed in said first path;

a second switching element disposed in said second path; and

control means for controlling said first and second switching elements to render them in a selected one of first and second states, said first and second switching elements being complementarily and alternately turned on and off in said first state, said first switching element being turned off and said second switching element being turned on in said second state;

said DC-arc initiation assisting circuit comprising:

high frequency voltage applying means for applying a high frequency, high voltage different from the high frequency voltage provided by said inverter means, between said first and second output terminals; and

current supply means operative when said first and second switching elements are in said second state, for supplying current to flow from the third path to the second path as said high frequency voltage applying means applies the high frequency voltage between said first and second output terminals.

4. The power supply apparatus according to Claim 3 wherein said current supply means comprises charging/discharging means which receives an output voltage from said rectifying means.

5. Power supply apparatus with a DC-arc initiation assisting circuit for assisting the initiation of DC arcing in an arc utilizing equipment, comprising:

an inverter for converting a DC voltage into a high frequency voltage;

a transformer having a primary winding receiving the high frequency voltage from said inverter and a secondary winding having a voltage-transformed high frequency voltage induced therein; and

a converter for converting said voltage-transformed high frequency voltage into a DC voltage and providing the resulting DC voltage between a first output terminal and a second output terminal, said first output terminal being more positive than said second output terminal and being adapted to be connected to a workpiece to be wrought by said arc utilizing equipment, said second output terminal being adapted to be connected to a torch of said arc

utilizing equipment;

said DC-arc initiation assisting circuit comprising:

a high frequency voltage generator for applying a high frequency, high voltage different from the high frequency voltage provided by said inverter, between said first and second output terminals; and

a charging/discharging circuit connected between said first and second output terminals for supplying current to flow from said first output terminal to said second output terminal.

6. AC/DC power supply apparatus with a DC-arc initiation assisting circuit used with arc utilizing equipment, said power supply apparatus comprising:

an inverter for converting a DC voltage into a high frequency voltage;

a transformer having a primary winding receiving the high frequency voltage from said inverter and two secondary windings each having a voltage-transformed high frequency voltage induced therein;

a first output terminal adapted to be connected to a workpiece to be wrought by said arc utilizing equipment;

a second output terminal adapted to be connected to a torch of said arc utilizing equipment;

a rectifier connected via each of first and second paths to said second output terminal and connected via a third path to said first output terminal, said rectifier rectifying the voltage-transformed high frequency voltages applied thereto in such a manner that current can flow through said workpiece and said torch, from said first path to said third path, or from said third path to said second path;

a first switching element disposed in said first path;

a second switching element disposed in said second path; and

a controller for controlling said first and second switching elements to render them in a selected one of first and second states, said first and second switching elements being complementarily and alternately turned on and off in said first state, said first switching element being turned off and said second switching element being turned on in said second state;

said DC-arc initiation assisting circuit comprising:

a high frequency voltage generator for applying a high frequency, high voltage different from the high frequency voltage provided by said inverter, between said first and second output terminals; and

a chargning/discharging circuit operative when said first and second switching elements are in said second state, for supplying current to flow from the third path to the second path as said high frequency voltage generator applies the high frequency voltage between said first and second output terminals.

The Patent Office

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Application No:	GB 9726705.8	**Examiner:**	M J Billing
Claims searched:	1 to 6	**Date of search:**	10 March 1998

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H2H WA.

Int Cl (Ed.6): B23K 9/06, 9/067, 9/095, 9/10, 10/00; H05H 1/36.

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,P	GB2302620A	(SANSHA) - Figs.1,3	1 at least
Y	GB1425831	(AUSTIN) - Figs.1,2; page 2 lines 1-13	1-6
Y	GB1090404	(BRITISH OXYGEN) - Fig.1; page 2 lines 89-126	1-6
X	EP0605879A1	(LINCOLN) - Fig.1; Abstract 1	1 at least
Y	EP0436021A1	(KOMATSU SEISAKUSHO) - Fig.6; column 7 lines 5-43	1-6
Y	WO93/23195A1	(HYPERTHERM) - Fig.1; Abstract, page 8 lines 4-17	1-6

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
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